📘 Industrial Chemistry | EndsEM Blueprint

📅 Based on previous papers: JAN 2026 | JULY 2025R | MAY 2025 | DEC 2023
🔍 Repeated questions, high-probability topics & must-know numericals with formulas

🔁 Repeated & High-Probability Questions

✓ *These concepts appear in **2+ question papers** — extremely likely for endsem.*

📌 Fuels & Combustion

- ✧ Procedure of **Proximate analysis of coal** with formula & significance of moisture JAN26 Q2A, MAY25 Q1C, DEC23 Q1C
- ✧ **Ultimate analysis** – determination of %C & %H (KOH & $CaCl_2$ tubes) JAN26 Q3B, MAY25 Q1Bi
- ✧ Bomb calorimeter: principle, construction, GCV determination formula JULY25 Q1Ci, JAN26 Q3A
- ✧ Six hurdles in **storage & transport of Hydrogen gas** JAN26 Q2B, JULY25 Q1Bii, DEC23 Q1Ba
- ✧ Biodiesel manufacturing from vegetable oil/animal fat – transesterification reaction JAN26 Q3C, DEC23 Q1Cb
- ✧ Classification of fuels (occurrence & reaction basis) JAN26 Q1D, JULY25 Q1Cii

⚛️ Spectroscopy & Molecular Analysis

- ✧ **IR Spectroscopy** – stretching & bending vibrations; functional group & fingerprint region JULY25 Q2B, DEC23 Q2Ca, MAY25 Q2B

- ✧ Number of fundamental vibrational modes (3N-5 / 3N-6) for molecules like CO_2, CH_4, H_2O JULY25 Q2C, DEC23 Q2Cb
- ✧ UV-Visible: Auxochrome, Bathochromic shift, Hypsochromic shift MAY25 Q2A, DEC23 Q2Ab
- ✧ Electronic transitions, Chromophore definition MAY25 Q2A, JULY25 Q2A

🧪 Corrosion & Protection

- ✧ **Wet corrosion mechanisms** – Hydrogen evolution & Oxygen absorption DEC23 Q3Ba, MAY25 Q3Ci
- ✧ Oxide film type on metals: Na, Cr, Al, Ca, Ag, Mo – Pilling Bedworth rule JULY25 Q3C, MAY25 Q3Cii, DEC23 Q3Ca
- ✧ Cathodic protection – method, advantages, limitations JULY25 Q3B, DEC23 Q3Cb
- ✧ Anodic vs Cathodic protection differences JULY25 Q3Bii, MAY25 Q3B
- ✧ Factors affecting corrosion (nature of metal & environment) DEC23 Q3Bb

📊 Analytical & Statistical Tools

- ✧ **Association of attributes** – Yule's coefficient Q, positive/negative/independence JAN26 Q11A, MAY25 Q4Ci, DEC23 Q4Ba, JULY25 Q4By
- ✧ pH meter calibration – principle and diagram with buffer solutions JAN26 Q12B, DEC23 Q4Ab, JULY25 Q4Bx
- ✧ Mean, Median, Mode, Standard Deviation, Coefficient of Variation MAY25 Q4Bii & Q4Cii, DEC23 Q4C, JULY25 Q4By
- ✧ Molality, Molarity, % concentration calculations JAN26 Q12A, JULY25 Q4Bx, MAY25 Q4Ai

📌 **Additional high-frequency:** Ignition temperature, renewable fuels, drawback of wind energy, Beckmann thermometer accuracy, LCV/HCV relation, significance of volatile

matter/ash in coal.

🧮 High-Probability Numericals & Essential Formulas

🔢 These numerical types have appeared in ≥2 exams – master the formulas & approach.

🔥 1. Bomb Calorimeter – Gross & Net Calorific Value (GCV / HCV & NCV / LCV)

GCV (cal/g) = **[(W + w) × ΔT] / m**
Where: W = water equivalent of calorimeter (g), w = mass of water (g), ΔT = temperature rise (°C), m = fuel mass (g)
NCV = GCV − **0.09 × H% × Latent heat** (latent heat = 580 or 587 cal/g)
🔷 *Tip: if H% not given, sometimes assume from ultimate analysis. JAN26 Q3A type: weight coal=1g, water equiv=2000g, water=700g, ΔT=2.48°C ⇒ GCV = (2700×2.48)/1 = 6696 cal/g ; NCV = 6696 − (0.09×5×580) = ...*

🧪 2. Proximate Analysis of Coal (Moisture, VM, Ash, Fixed Carbon)

Moisture% = [(Initial mass − mass after 105-110°C) / Initial mass] × 100
Volatile Matter% = [(mass before VM heating − mass after covered heating at 950°C) / Initial mass] × 100
Ash% = [(Residue after heating without lid to constant weight) / Initial mass] × 100
Fixed Carbon% = 100 − (M% + VM% + A%)
✓ *Example: MAY25 Q1Cii (2.5g sample, residue after moisture=2.20g, after VM=1.10g, final ash=0.20g) ⇒ M% = (0.3/2.5)×100 = 12%; VM% = (2.20-1.10)/2.5 ×100 = 44%; Ash% = 0.20/2.5×100 = 8%; FC = 36%.*

🧪 3. Ultimate Analysis – % Carbon & % Hydrogen from combustion

%C = (Increase in weight of KOH tube × 12/44 × 100) / mass of coal sample
%H = (Increase in weight of $CaCl_2$ tube × 2/18 × 100) / mass of coal sample
🔷 *JAN26 Q3B: KOH tube gain = 0.69g, $CaCl_2$ gain = 0.18g, mass = 1g ⇒ %C = (0.69 × 12/44 ×100) = 18.82% ; %H = (0.18 × 2/18 ×100) = 2%.*

⚖️ 4. Molality & Concentration Units

Molality (m) = moles of solute / mass of solvent (kg)
Moles = given mass / Molar mass
📘 *JAN26 Q12A: 10.5g urea (NH_2CONH_2, M=60 g/mol) in 100g water ⇒ moles = 10.5/60 = 0.175; kg solvent = 0.1 ⇒ molality = 1.75 m.*
Also Molarity = moles/volume(L); %(w/v) = (mass solute/vol solution)×100.

📈 5. Association of Attributes (Yule's Coefficient Q)

Construct 2×2 table: (A) (α) totals
(B) a b (B)
(β) c d (β)
Q = (ad − bc) / (ad + bc)
Q > 0 → Positive association; Q < 0 → Negative; Q = 0 → Independence
📌 *DEC23 Q4Ba(i): N=100 lakhs, (A)=20 lakhs literate, (B)=15000 smokers, (AB)=1200 literate smokers. Compute a=1200, b=18800, c=13800, d=?? and find Q.*

📊 6. Standard Deviation, Coefficient of Variation & Mean Deviation

For ungrouped: $\sigma = \sqrt{[\ \Sigma(x - \bar{x})^2 / N\ ]}$, $CV = (\sigma / \bar{x}) \times 100$
For grouped data: $\sigma = \sqrt{[\ \Sigma f\ (x - \bar{x})^2 / \Sigma f\ ]}$
Mean Deviation = $\Sigma|x - \bar{x}| / N$ (or $\Sigma f|x - \bar{x}|/\Sigma f$)
📘 *MAY25 Q4Bii (heights & persons) & DEC23 Q4Ca (class frequency).*

🧴 7. GCV/NCV relation & corrected formula

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NCV = GCV − 0.09 × H% × latent heat
Latent heat of steam = 580 cal/g (often) or 587 cal/g.
🔁 DEC23 Q1Cii: Coal contains 6% H, GCV=8640 cal/g ⇒
NCV = 8640 − 0.09×6×580 = 8640 − 313.2 = 8326.8 cal/g.
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✅ **Extra practice:** Calculate median, mode, pH calibration steps, % of volatile matter from coal data, fundamental vibrations number (like CO_2: 3N-5 = 4 modes, CH_4: 3N-6 = 9 modes).

📐 Quick Formula Reference Sheet

Concept	Formula
Gross Calorific Value (Bomb Cal.)	GCV = [(W+w) × ΔT] / m
Net Calorific Value	NCV = GCV – 0.09 × H% × L (L=580 cal/g)
Moisture % (Proximate)	(loss in weight / initial mass) × 100
Volatile Matter %	(loss in covered heating / initial mass) × 100
Ash %	(residue after open heating / initial mass) × 100
% Carbon (Ultimate)	(Δwt KOH tube × 12/44 × 100) / sample mass
% Hydrogen (Ultimate)	(Δwt $CaCl_2$ tube × 2/18 × 100) / sample mass
Molality	moles of solute / kg of solvent
Yule's coefficient Q	(ad – bc)/(ad + bc)
Vibrational modes (linear)	3N – 5
Vibrational modes (non-linear)	3N – 6
Standard Deviation (sample)	$\sqrt{[\ \Sigma(x - \bar{x})^2 / (N)\ ]}$ for population

Concept	Formula
Coefficient of Variation	$(\sigma / \bar{x}) \times 100\%$

🎯 Topics that will DEFINITELY appear in EndsEM Exam

- ✓ Proximate Analysis of Coal
- ✓ Bomb Calorimeter (GCV/NCV)
- ✓ Hydrogen Fuel – Storage & Transport Challenges
- ✓ IR Spectroscopy (Stretching/Bending, fingerprint region)
- ✓ Biodiesel – Transesterification Reaction
- ✓ Wet Corrosion Mechanisms (H_2 evolution & O_2 absorption)
- ✓ Association of Attributes & Yule's Coefficient
- ✓ pH Meter Calibration & Diagram
- ✓ Numerical on %C & %H from combustion data
- ✓ Numerical on Proximate / Ultimate / Calorific value
- ✓ Oxide Films (Pilling Bedworth) – Na, Al, Cr, Ag, Ca, Mo
- ✓ Cathodic / Anodic Protection
- ✓ Molality & concentration based numerical
- ✓ Standard Deviation & Coefficient of Variation
- ✓ Classification of Fuels (primary/secondary, natural/manufactured)

📢 **Instructor note:** Based on JAN 2026, JULY 2025, MAY 2025, DEC 2023 pattern, long answer questions often combine coal analysis & hydrogen hurdles. Spectroscopy (IR/UV) carries 6 marks, corrosion 6–9 marks, and statistics (association + mean deviation) 6 marks. Prioritize numericals from bomb calorimeter, proximate analysis, and attributes. Diagrams mandatory for pH meter, bomb calorimeter, cathodic protection.

📌 Exam Strategy – Most Repeated Long Answer Topics (≥6 marks)

- Proximate analysis procedure + significance
- Hydrogen storage & transportation difficulties
- Bomb calorimeter – principle & working
- IR spectroscopy – vibrations & fingerprint
- Association of attributes derivation & interpretation
- Cathodic protection (sacrificial / impressed current)
- Wet corrosion mechanisms (with examples)
- Biodiesel preparation (reaction, advantages)

🔥 **Numerical prediction:** One numerical from **Bomb calorimeter (GCV/NCV)** ; one from **Proximate analysis or %C & %H** ; one from **Molality or association of attributes (Yule's Q)** ; one from **Standard deviation / CV** (grouped/ungrouped).
✨ Formulas for all above are given – practice with past paper values.

🧪 Compiled from JAN 2026, JULY 2025R, MAY 2025, DEC 2023 question banks | High-repetition blueprint for Industrial Chemistry endsem
📍 Neat diagrams & stepwise calculations fetch full marks – practice writing balanced reactions & labeled sketches.